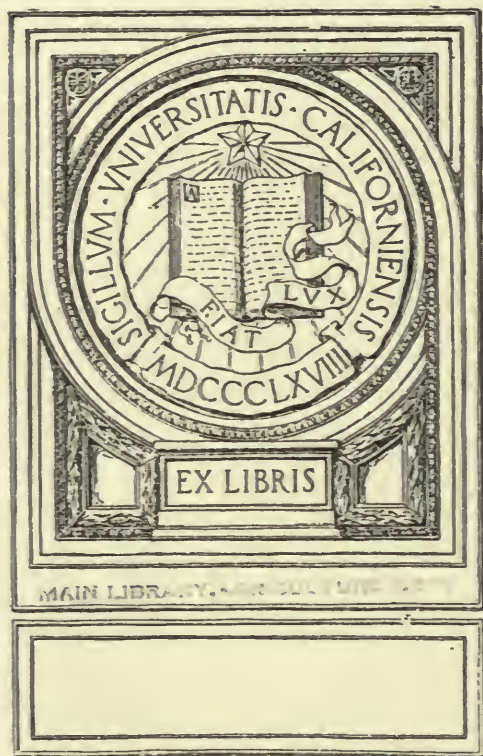






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VICTORIA, B.C.:

Printed by WILLIAM H. CULLIN, Printer to the King's Most Excellent Majesty.

1914.

PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF AGRICULTURE

BULLETIN No. 58

FARM STORAGES FOR FRUITS & VEGETABLES

By

EDWIN SMITH, B.Sc.

In charge of Storage and Transportation Investigations



THE GOVERNMENT OF
THE PROVINCE OF BRITISH COLUMBIA

PRINTED BY
AUTHORITY OF THE LEGISLATIVE ASSEMBLY.

VICTORIA, B.C.:

Printed by WILLIAM H. CULLIN, Printer to the King's Most Excellent Majesty.
1914.

DEPARTMENT OF AGRICULTURE,

VICTORIA, May 13th, 1914.

Hon. Price Ellison,

Minister of Finance and Agriculture,

Victoria, B.C.

SIR,—I have the honour to transmit herewith Bulletin No. 58, entitled “Farm Storages for Fruits and Vegetables,” which has been compiled by Edwin Smith, B.Sc., Precooling and Cold-storage Investigator attached to the Horticultural Branch of this Department.

I have the honour to be,

Sir,

Your obedient servant,

WM. E. SCOTT,

Deputy Minister.

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DEPARTMENT OF AGRICULTURE.

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Farm Storages for Fruits and Vegetables.



IN CANADA it is estimated that the yearly loss due to unsuitable storages is no less than \$1,000,000. The saving that could be made by properly storing farm products, if proper storages were made use of, would be many times the above amount. If we are not concerned as to the physical welfare of perishable products between the time of harvesting and the time of consumption, we are then passing over one of the greatest sources of losses to the grower.

Reducing the cost of packing such products as apples by extending the packing season over several months instead of crowding it into a few weeks when labour demand is at its highest should be considered from the storage point of view. In some districts it is common to pick longer-keeping varieties and store immediately in orchard-boxes in farm storages. This gives the fruit immediate storage, and reduces the cost of putting it on the market, since it can be packed up during the winter months when time is not so valuable; especially where the grower depends



Fig. 1. The farm cold storage of George Smith, South River, N.J., using the Madison Cooper Gravity Brine System.

much on family help, and only a few hours each day can be devoted to packing. Besides lengthening the packing season, the marketing season is also lengthened. By holding back in farm storages part of the yearly production of apples and vegetables the market is stronger in the fall, and as a rule higher prices will be brought by the stored produce.

In a new agricultural region such as British Columbia there is always a lack of proper farm storages, mainly due to the dearth of obtainable information. The

purpose of this bulletin is to give fruit and vegetable growers such information as will better enable them to solve their storage problems.

TYPES OF STORAGES.

There are two main types of fruit and vegetable storages, those using some means of lowering the temperature below that of the outside air, called "cold" storages, and those depending upon temperatures secured from atmospheric changes called "cool" or "common" storage. The first class may be subdivided into those using mechanical refrigeration and those using ice as a refrigerant. The other class may be subdivided into various types of the common or cool storage. There

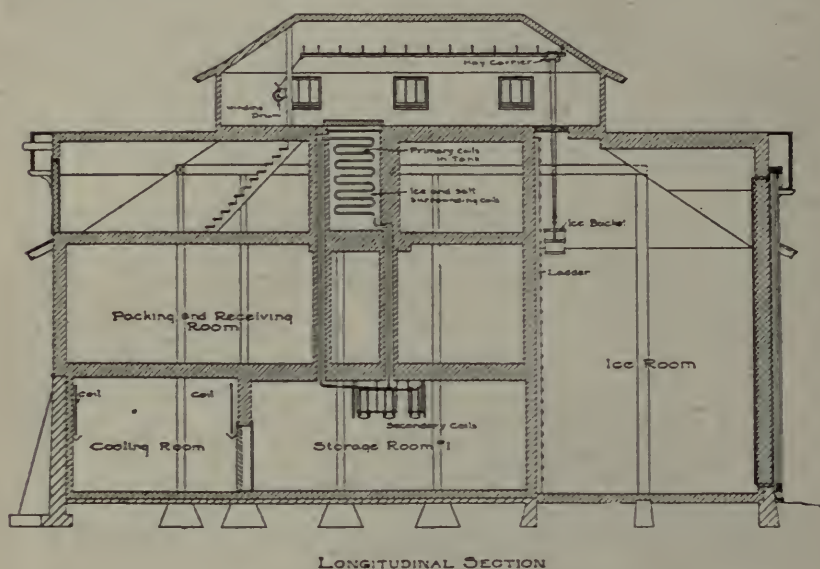


Fig. 2. Diagram showing the arrangement of the farm cold storage of Fig. 1.

are also pits and trenches, used more for vegetables than fruits. All these embody similar general principles and are constructed to suit the commodity to be stored.

MECHANICAL COLD STORAGES.

Mechanical or chemical cold storage is based upon the laws of physics which show that heat is taken up by a liquid when evaporated, and that the condensation of a gas varies with the temperature and the pressure applied. Thus such fluids as ammonia, carbon dioxide, and sulphur dioxide, which have low boiling-points (-27.4° Fahr., -110° Fahr., and -14° Fahr., respectively), are used. At ordinary temperatures these compounds are gases, but under extreme pressure and then by cooling in condensers the gases are condensed to liquid form. Upon expanding in pipes placed in the storage-rooms these liquids evaporate very rapidly, and in doing so use up the heat within reach of the pipes, thus lowering the temperature of the room, or producing cold in it. To secure this kind of refrigeration it is necessary to have a mechanical compressor with a power plant to operate it. This form of refrigeration is most economically used in large cold-storage plants, but on account of the expense is not ordinarily adapted to farm conditions.

ICE COLD STORAGES.

DIRECT REFRIGERATION.

Ice is now much made use of as a refrigerant. By placing ice in bunkers or special ice-rooms, usually situated above a properly insulated storage-chamber made with drip and condensation pans, a temperature of 38° to 40° Fahr, is secured. For

further information in this connection get Dominion Bulletins, No. 20, entitled "The Use of Ice on the Farm," and No. 23, entitled "Cold Storages and the Cold Storage Act," furnished free by the Dairy and Cold Storage Commissioner, Ottawa, Ontario.

GRAVITY BRINE REFRIGERATION.

With this system crushed ice is melted in a primary tank by adding salt, which process takes up heat rapidly from coils of brine placed in the tank and connected with coils in the storage-chambers below. The cooling starts the brine circulating in the coils, and the cold brine is continually removing the heat from the storage-room below. Any desirable temperature down to about 8° Fahr. may be obtained by regulating the melting of the ice by increasing or decreasing the amount of salt that is used in the primary tank. Very even temperatures are obtained, and this feature, together with the possibility of low temperatures, gives the system all

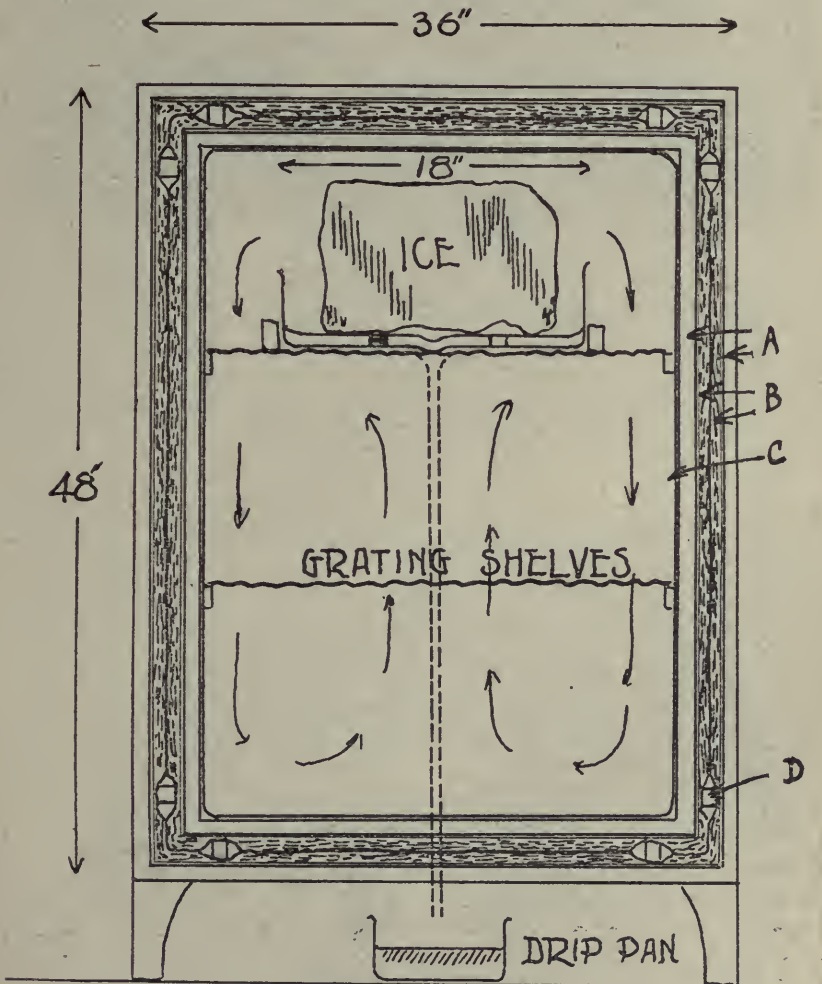


Fig. 3. Diagram of a home-made refrigerator or ice-chest.

the advantages of a mechanical refrigerating plant. Its cost makes it adaptable to small farm storages as well as larger commercial plants. The system is covered with patents. (See publication "Cold," published at Calcium, N.Y.)

FARM REFRIGERATORS AND ICE-BOXES.

Farmers storing ice can save a large amount of ice, and economize, if the refrigerator is built on right principles. Have the box built with good insulation; have door fit tightly; have ice-rack properly situated; and have drip and condensation pan built to ensure dryness.



Fig. 4. A British Columbia fruit-storage house built by Thos. Brydon, Royal Oak, V.I. It has often saved its cost by holding fruit to suit the demands of local markets in Victoria. Note the ventilators at the base of the building to admit the cold night air.

The better insulation, the less ice used, and the colder the temperature. Most refrigerators sold are not sufficiently insulated. With a 3-inch wall of cork-board lining, a fairly good insulation for an ice-chest would be provided. Linofelt is shown in the accompanying sketch, as this probably would be more convenient for most builders.



Fig. 5. A Wenatchee Valley fruit storage built by Dr. Whitney, of Cashmere, Wash. Note the ventilating system.

Refrigerator shown in sketch, Fig. 3, is 36 inches wide, 30 inches deep, and 48 inches high, outside measurement. Ice-pan is 18 x 22 inches, with double bottom to catch drip. Drain-pipe has funnel at the upper end to catch the drip, and still let pan slide out of ice-chamber for recharging. Shelves should be grating to allow free circulation of air. Walls and door are outside lining of $\frac{7}{8}$ -inch V-joint; two layers of 1-inch sheets of linofelt (three layers is desirable to make an extra good refrigerator); an inner sheathing of $\frac{7}{8}$ -inch V-joint, and this lined with galvanized

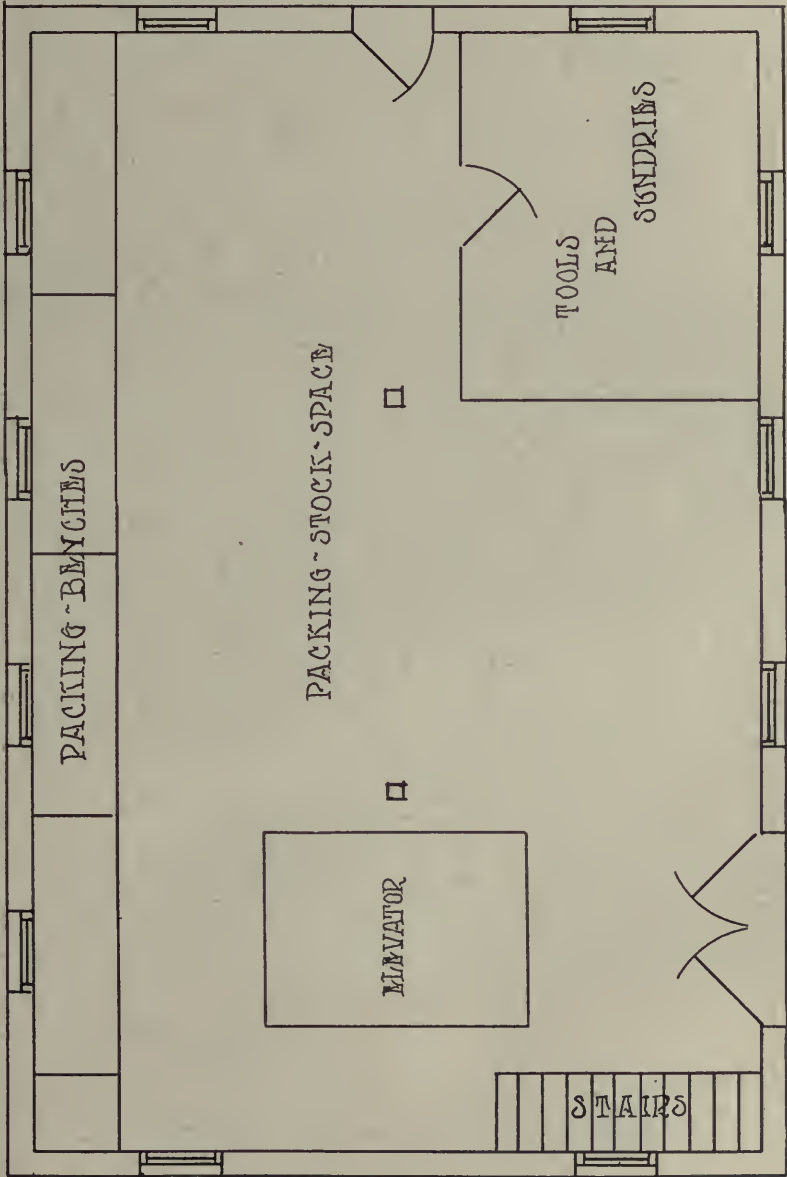


Fig. 6. Plan of a fruit storage and packing house. Capacity 2,500 to 3,000 boxes.

iron, with joints well soldered so that ice-chest may be thoroughly washed out without danger of water reaching the insulation. The door is of the same construction as the walls, setting in a bevel casing with felt jamb. It is very important that the door fits very tightly and still swings freely.

It is not necessary to have a vent to "let off" warm air, as the ice "uses up" the warm air in melting, and any opening only melts the ice faster by letting in warm air. The sole need of ventilation is to provide pure, fresh air for the provisions, and this is got by washing out the inside occasionally, using good washing-powder, letting refrigerator stand a few hours with doors open to dry well and sweeten.

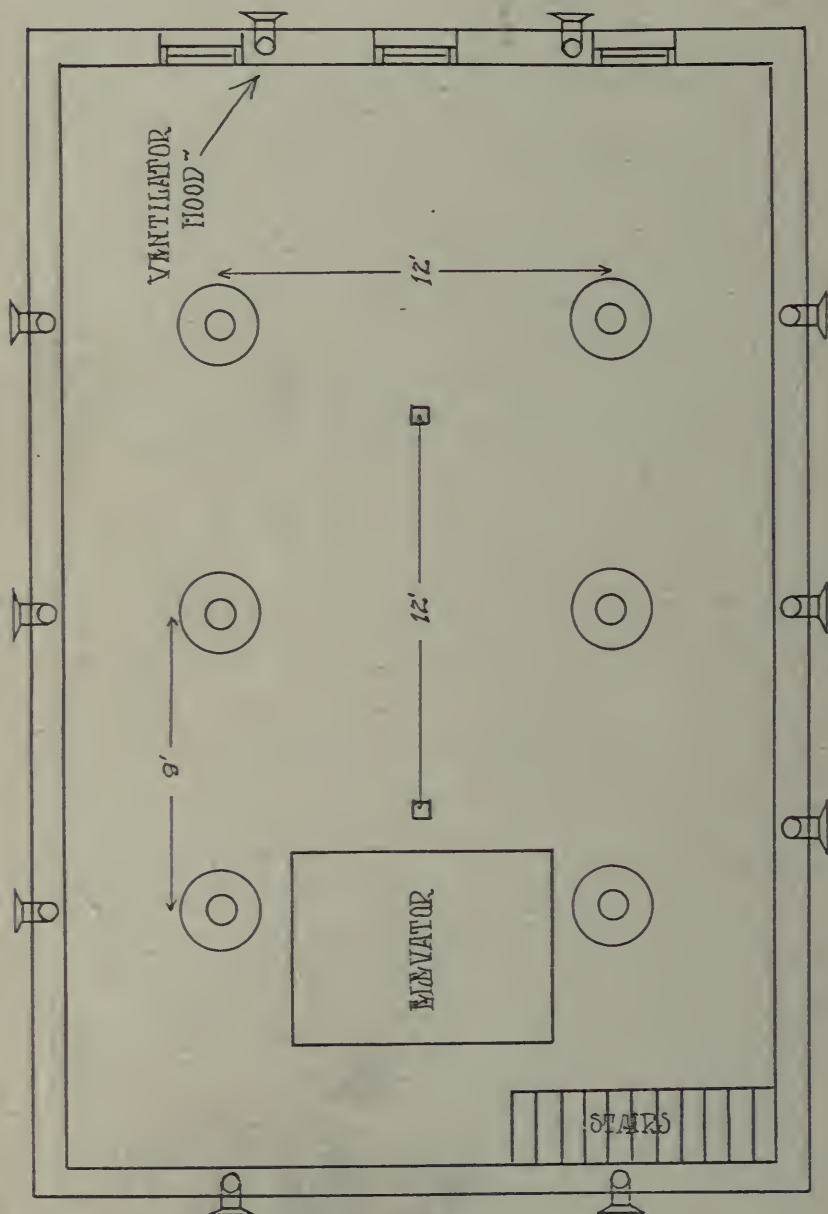


Fig. 6. Basement.

The above type may be made in larger sizes on the same principles. In erecting a refrigerating-room, partition off ice-chamber with sufficient insulation that the warm air passes through a small space to the top of the ice-chamber, and the cold air is carried toward the bottom of the provision-chamber. This sets up air currents that are more lively and effective.

COMMON OR COOL STORAGE.

The third main type of storage mentioned is the common or cool storage. Much more can be accomplished with this type than is ordinarily realized if the low temperatures of the cool nights of spring and fall are made use of, as they usually are not. If suitable varieties of apples and vegetables are chosen, it is not necessary to have a cold storage on farm in order to store them in good shape till the following spring. Great loss is each year experienced by having inferior common storages, and by storing unsuitable varieties of fruits and vegetables.

PRINCIPLES OF FRUIT AND VEGETABLE STORAGE.

There are six fundamentals that must be kept in mind in constructing a storage for fruits and vegetables: (1) Maintenance of low temperatures; (2) protection from frost; (3) provision of sufficient moisture; (4) avoidance of a wet and stagnant atmosphere; (5) protection from heating, for heating is the natural result of the accumulation of much fresh vegetable matter; and (6) protection from change of temperature.

The amount of protection from frost varies with the severity of the climate. In British Columbia the Lower Mainland and Island regions will not require the

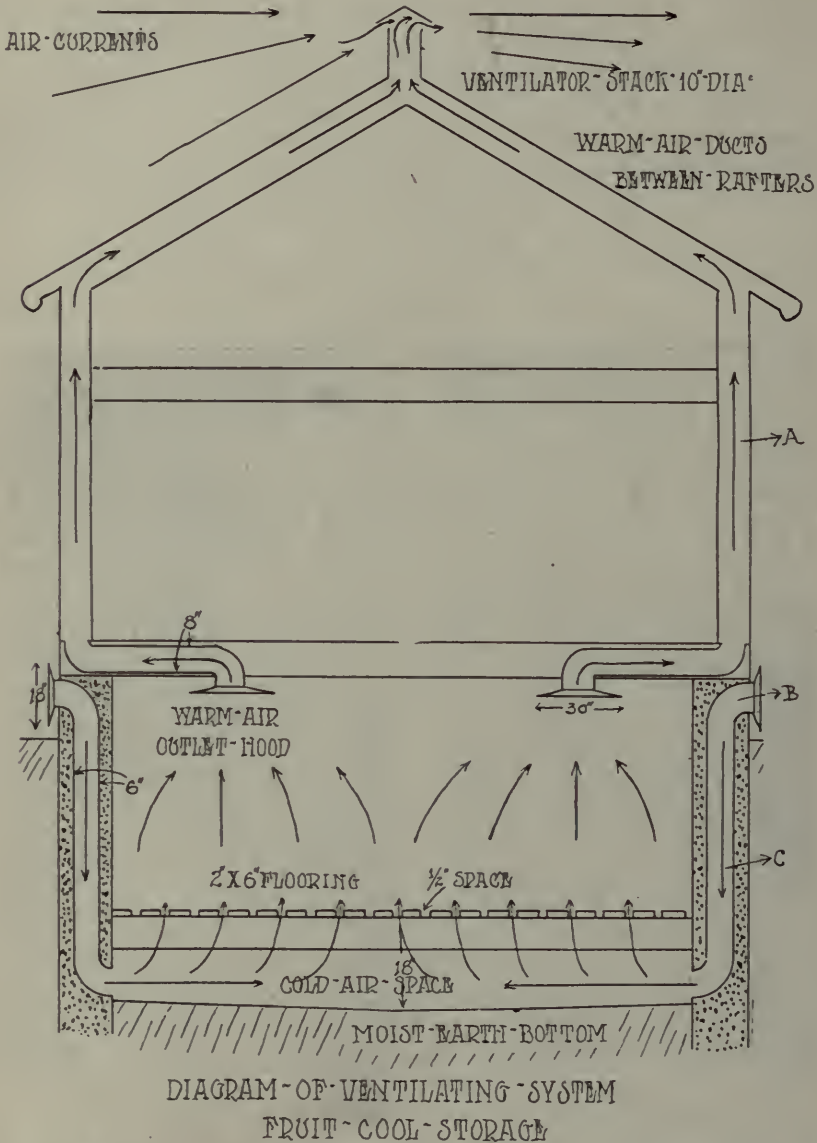


Fig. 7. Basement of Dr. Whitney's Wenatchee Valley storage, showing floor and wall construction.

same construction demanded in the Interior regions. The natural heat of vegetable matter stored is held within the storage, and the cold is kept out by walls that transmit heat very slowly. Since air-spaces in which the air is kept confined are very poor conductors of heat, it is necessary to build the walls of materials having a great many minute air-spaces. In protecting from frost, the construction is at the same time made such that it maintains low and even temperatures within when the weather is warm without.

To give a storage sufficient moisture to prevent excessive evaporation, and also give an air not too moist nor stale, is produced by proper ventilation. Ventila-

tion also keeps fresh vegetable matter from heating. The amount depends much upon the product stored, as there is a great difference between the storage of a leaf or root product, such as cabbage or beets, and one which is a stem, as the potato, or one which is a fruit, such as the apple. Leaves require most ventilation, and in some cases, such as celery, need to be kept in a slowly growing condition.



- A. Warm Air Ducts between Studding
- B. Cold Air Intake Hood
- C. Galvanized Sheet Iron Tube imbedded in Concrete Wall

Fig. 8. Diagram of the ventilating system used in "Iceless Refrigeration," with transverse section of fruit storage and packing house.

By ventilation the storage is kept cool in early fall and spring by admitting the cold night air and by closing the building during the day. Thus in constructing

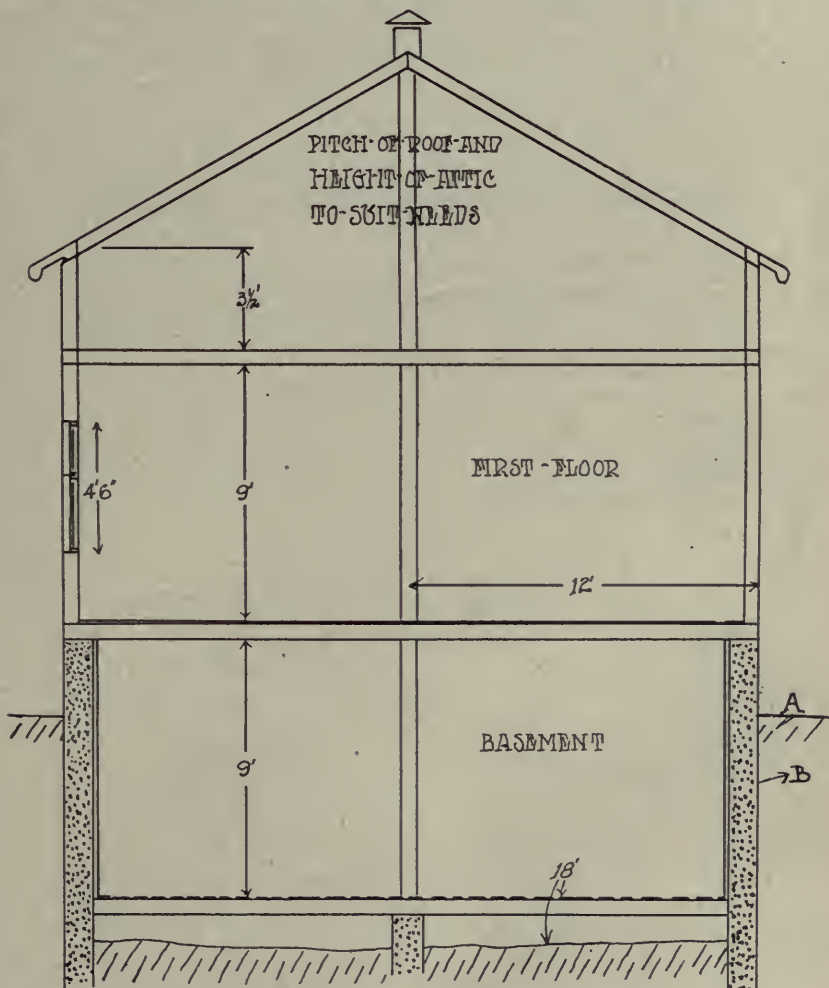
a common or cool storage the problem of keeping low, even temperatures with an atmosphere having sufficient but not too much moisture resolves itself into having properly constructed walls and an efficient system of ventilation.

PART 1.—FRUIT STORAGE.

In this publication it is the aim to bring together desirable points taken from many designs investigated, and summarize these in plans that make a complete and modern cool-storage and packing house based upon principles thoroughly tested.

A FRUIT PACKING-HOUSE AND STORAGE.

Location.—In selecting a site, remember exposure, light, drainage, and convenience. With a basement storage better ventilation is had by having building at



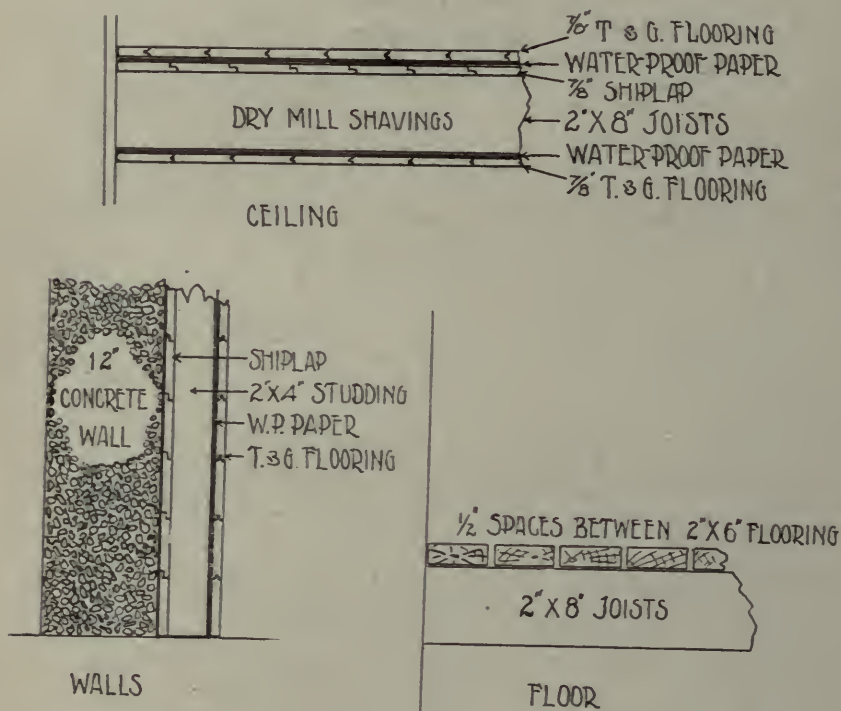
TRANSVERSE SECTION

A. Drive
B. 12" Concrete Wall

right angles to the prevailing winds. If storage is above ground, building should run north and south, so exposure to autumnal sun will be avoided, as this has a great effect on the temperature within the storage. The one other consideration is light. Other things being taken care of, the building should be placed to give abundance of light to packing-benches.

Adaptation.—The building must suit local conditions. A two-story structure as shown in Figs. 5 and 6 is the most practical. In this the first floor is used as packing-shed and the basement for storage, an elevator conveying the fruit between the two. The attic, constructed to the height desired, may be used to store orchard-boxes, box-shook, and other sundries. By this arrangement, as soon as fruit is packed it receives immediate storage in a low temperature, whereas, if the packing-house itself is used as a storage, the temperature of the fruit cannot be lowered until after the packing season is entirely over. Besides having a lower temperature in early fall, the other great advantage of having a basement storage lies in the decreased danger from frost in midwinter.

Size and Capacity.—These are optional. This design is an arbitrary size, being 24 x 36 feet. It is considered large enough to store the winter varieties of apples in the average 10-acre orchard, as it will contain between 2,500 and 3,000 boxes of fruit in the basement. If a grower finds that his needs demand a larger building, the size may be fixed by figuring a box of apples at 2½ cubic feet, which allows for air-spaces and alleys.



Construction.—A packing-shed may be cheaply built, as it is used but a few months during the year. Reduce cost of this and use money saved in an elevator and in suitable ventilation. The basement walls are of 12-inch concrete construction, and upper portion of the building is of wood.

Insulation.—Air, being a poor conductor of heat, has been much used in various ways to provide sufficient insulation in the walls of storages, both common and refrigerated. The old custom was to provide "dead-air spaces" in the walls of storages by the use of furring, studding, etc., but this should not be used.

Cork, mineral wool, linofelt, lith. hair-felt, and dry mill shavings are some of the more common insulators used at present. Dry mill shavings, when used sufficiently thick and well protected from moisture by linings of water-proof building-paper on both the inside and outside, provide an excellent insulator. For

storages above ground from 12 to 16 inches of shavings are recommended, depending upon the climate, with two ply of sheathing or siding both on the inside and outside. However, in basement storages as described below, this amount of insulation is not required.

Basement.—The basement is dug to a depth of 7 feet below the surface of the ground. Starting 1 foot below the bottom level of the basement, a concrete wall is constructed, having a base width of 18 inches and top width of 12 inches, the outside measurement of which is 24 x 36 feet, to a height of 10 feet 6 inches above the bottom level of the basement, leaving the forms in place, as is shown in Fig. 7. Embedded in the concrete are 6-inch G.I. tubes, as shown in drawings. The forms used in building the concrete wall are left in place, with 4-inch studding attached. On the studding fasten one ply of water-proof building-paper and a cellar-wall lining of $\frac{7}{8}$ -inch T. and G. flooring, or shiplap. If the building is in severe climate, build the concrete form with 8-inch studding, using water-proof building-paper on both sides of studding and filling the spaces with dry mill shavings.

The floor of the basement is made of 2- x 6-inch pieces laid from $\frac{1}{2}$ to $\frac{3}{4}$ inch apart on 2- x 8-inch joists, the floor-level being 18 inches above the earth bottom.

The ceiling of the basement consists of one ply of W.P. paper on the under-side of the joists, then a covering of $\frac{7}{8}$ -inch T. and G. flooring, this being the exposed ceiling. On the upper side of the joists the flooring of the packing-house consists of $\frac{7}{8}$ -inch shiplap; one ply W.P. paper; then one layer of $\frac{7}{8}$ -inch T. and G. flooring. The 8-inch spaces between the joists are filled with dry mill shavings.

Unless first floor is to be later used as a storage-room, the wall-construction should be siding on 2- x 4-inch studding, with ceiling of whatever floor is required in attic.

Attic.—Build to suit needs of builder.

Elevator.—Elevator should be of stock size to suit builder, at end of building near out-loading door, with stairway close by. If impossible to supply an elevator, the basement should have an outside door:

Windows.—The packing-shed has a window $2\frac{1}{2}$ feet wide by $4\frac{1}{2}$ feet high for each packing-bench, with two similar windows at either end. The basement has three windows at the end of the least exposure, each being $2\frac{1}{2}$ feet wide by 2 feet high and double sashed.

Doors.—The packing-shed has an entrance from the drive 6 feet wide by 6 feet 4 inches high, double doors swinging each way. A single door is at opposite end, 2 feet 6 inches wide by 6 feet 4 inches high. The elevator has doors that may be closed underneath the lift when the same is on a level with the first floor.

Ventilation.—The system of ventilation used may be best understood by studying the diagram in Fig. 8. Its great efficiency comes from securing low temperatures in the fall by gathering up the cold night air without the storage by means of hoods and conducting it through tubes to the space underneath the flooring. Here the temperature of the already cool air is further greatly lowered by passing over the surface of the moist earth bottom, which is kept saturated by flooding. This causes rapid evaporation of the water, which requires a great deal of heat to be taken from the air. As the air spreads out over the bottom of the basement an even distribution of cold air is given to all parts of the storage. The warm air in the storage above rises with the draught of the ventilation-stack above the roof, the same as the chimney from a furnace, tending to make a vacuum in the storage-room. As a result the cold air underneath rises through the $\frac{1}{2}$ -inch spaces between the 2- x 6-inch flooring, and takes the heat from the fruit, gradually reducing the temperature of the storage-room until it is the same as that outside the storage. In most apple regions of British Columbia the night temperature of the air reaches 32° Fahr. at apple-harvesting time. The storage atmosphere does not get too dry due to the moisture underneath the storage, nor overmoist nor stagnant on account of the constant circulation of air.

Where the earth is very dry or the soil cannot be kept saturated by frequent flooding, large surfaces of water are exposed to the circulation of air by placing long concrete pans or basins under the floor of the storage, well filled with water. If

the soil is anyways retentive of moisture, the expense of these basins may be saved by having pipes under the storage by means of which the earth bottom may be periodically flooded to saturation during the fall.

The ventilation system must be complete in every detail or poor results will follow. In places where "iceless refrigeration" is being used there are fruit storages not adequately ventilated, and from the latter the fruit comes in the spring in a damp and mouldy condition, with from 10 to 15 per cent. more decay in such varieties as the Ben Davis, due to the air stagnancy of the storage, notwithstanding that there were no sub-storage moisture-basins as there were in the "iceless refrigeration" storages. They were storing 3,000 boxes of apples, and the 10 per cent. loss due to the stagnancy of the atmosphere and the higher temperatures would equal the cost of the ventilating system in one year.

Detail of Construction of Ventilators.—The cold-air intake tubes are built of galvanized iron and embedded in the concrete wall at distances from 8 to 15 feet to suit convenience. These should not be less than 6 inches in diameter, and may be made of wood in box form if care is used in making. At the mouths, which open at right angles from the upright shaft toward the outside of the building and as far above the surface of the ground as the wall will allow, are flanged hoods 18 inches in diameter. To fit into the mouth of each tube is a cap, shown in Fig. 9, with holes in its flange to regulate the amount of air that is to be taken in. By shoving the cap full in the tube the air-circulation from without may be shut off entirely.



Fig. 9. Cold-air intake and hood for "Iceless Refrigeration." The adjacent door is used in ventilating the packing-house when it is also used as a storage.

The outlet or warm-air ducts are made of galvanized iron 8 inches in diameter and spaced about 15 feet apart. Flanged hoods 30 inches in diameter are at the mouths on the lower end of the ducts near the ceiling of the storage, and these openings are also regulated by a cap or damper, though commonly left open continually except in times of very severe weather. The warm-air ducts have an elbow in the ceiling, and are carried between the joists to the outside of the building and connected to a space between the studding and rafters, which is well ceiled and serves the purpose of an air-duct. In large storages where more draught is required to carry off the warm and foul air, the outlet ducts should be from 12 to 15 inches in diameter, and should rise direct from the hoods to the ventilator-stacks on the roof. Thus, having larger outlet ducts, it is not necessary to have as large a number of them as of intake ducts, since with the latter the aim is to secure an equal distribution of cold air in all parts of the storage:

Bill of Material for Construction.—

60 yds. gravel.
50 bbls. cement.

38 pieces 2" x 8" x 24', joists, first and second floor.
 19 pieces 2" x 6" x 24', joists, third floor.
 46 pieces 2" x 4" x 18', studding for sides and ends.
 38 pieces 2" x 4" x 16', rafters.
 2,000 feet 2" x 6", basement floor.
 1,000 feet shiplap.
 2,000 feet flooring, walls, and ceiling.
 2,000 feet siding.
 1,200 feet 1" x 6" sheeting for roof.
 12 M. shingles.
 100 feet V-joint for doors.
 150 feet 1" x 10".
 500 lineal feet 1" x 6", D.D.
 6 pieces 6" x 6" x 18', beams.
 9 pieces 6" x 6" x 9', posts.
 11 windows.
 10 rolls Neponset water-proof paper.

Method of Operating.—As soon as the outside air gets colder than the temperature of the storage, and after 7 p.m. during fall days, the outside ventilator-caps,



Fig. 10. Fruit storage and packing house of Capt. R. J. Graham, Cashmere, Wash. Note the ventilator-stacks along the roof.

shown in Fig. 9, are opened and cold air passes through the storage during the night. Next morning close the ventilators and the frost-proof construction will retain low temperature during the day while it is warm outside. In winter months open ventilators only on warm days when temperature is above freezing. If fearing danger from freezing, a banking of snow, straw, or other roughage about the outside wall will act as a protection.

RULES FOR STORING APPLES.

Store only mature and sound fruit of suitable keeping varieties.

All fruit to be stored must be carefully handled without bruising.

Place fruit in a low temperature at once after picking. Do not allow it to stand about in a warm temperature.

Fruit may be stored before packing, giving the advantages of: (1) Immediate storage; (2) assurance of only sound fruit by packing at the time of the sale; (3) removing the necessity of repacking at time of removal; and (4) in the reduction of the cost of packing, as well as other minor advantages.

With proper winter varieties there are equal advantages when the fruit is packed before storing, such as: (1) Saving of space in storage; (2) beneficial effect of wrapping-paper on keeping qualities; and (3) convenience in handling at the time of sale, etc. It is quite generally the practice to store loose in orchard-boxes when a cold storage is not used.

Make frequent inspections of stock to determine how it is standing up in storage to prevent loss from unexpected deterioration.

Keep even and low temperatures, with an active circulation of air at all times that the outside temperature is permissible. Apples keep best at a temperature of 31° Fahr. They are liable to freeze at temperatures lower than 29° Fahr.

PART 2.—VEGETABLE STORAGE.

The cheapest equipment to supply that a farmer can use to store vegetables is the pit or trench, though a certain amount of loss is usually encountered in this kind of storage. In the pit or trench may be stored such crops as the potato, cabbage, celery, carrot, beet, and other root crops.

THE STORAGE-PIT.

It is very necessary to have good drainage, and this may be found on a ridge or slope having a loose or gravelly subsoil. The site must be well protected, for if exposed to prevailing winds that sweep away the snow and penetrate the soil with extreme cold during winter, there is just as much danger from loss as there is if the site is such as is apt to warm up rapidly with a thaw, then freeze again. Secure a place that has an even exposure and one fairly sure to hold a good depth of snow. Convenience is a point, as there are times when pits need to be opened in the winter and a near-by location helps.

Pits should be dug from 12 to 18 inches below the surface. The depth depends upon the moisture in the soil, as a deeper pit can be made in dry places. A convenient size for a pit is 8 x 18 feet, although the length is varied to suit needed capacity.

Roots or tubers are placed to a depth of from 3 to 4 feet. They must be dry and clean, and a layer of straw should be placed underneath the vegetables when starting the pit. A layer of hay, straw, or other roughage is then placed over the vegetables to a depth of 6 to 8 inches, then as the weather grows colder soil is thrown over this to prevent freezing. This should be done gradually as winter advances. The depth of the soil covering varies with the temperature. Districts having winter temperatures as low as zero will need over a foot of soil, with a greater depth, especially at the base of the pit, as the temperature goes below this mark.

Pits demand ventilation to keep vegetables from rotting, and this is done by not entirely covering the pit at intervals of 6 or 8 feet and here inserting tufts of straw. Cupolas as shown in Fig. 11 are sometimes used for the same purpose and thus prevent the entrance of moisture. These should have straw placed in the opening upon the approach of winter. Some form of ventilation is absolutely necessary to ensure the escape of damp and stagnant gases, so as to have the product come out in prime condition when the pit is opened.

TRENCHES OR FURROWS.

Vegetables made up of leaves such as cabbage and celery will not keep well when stored in large masses, so the pit does not serve well for these products, and in its place the furrow or trench is used with good results.

For cabbage the trench is made 5 or 6 inches deep, and the cabbage is set in on stem, with a layer of hay or straw on top, then soil thrown over this. Another method for cabbage is to plough a double furrow and to place a width of three

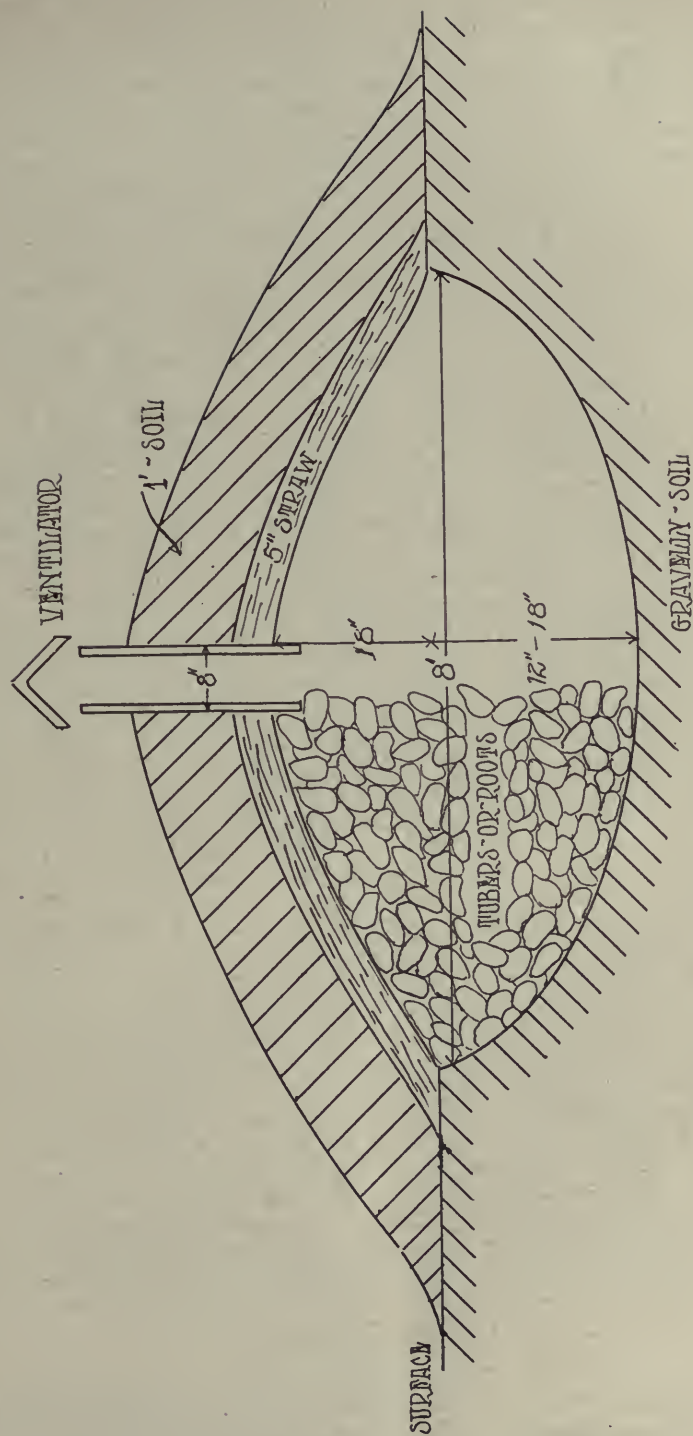


Fig. 11. Diagram showing the section of a vegetable-pit.

heads in the furrows. Others pile the cabbage in windrows, without paying attention to the stems, then cover with 6 or 8 inches of soil, allowing the cabbage to freeze, but being protected so that it will not thaw out until it is ready to be marketed.

With celery a double furrow is ploughed and the remaining lumps cleaned out, giving a level bottom. It is usually made between two rows of celery, and a trench of this size provides for ten or twelve rows. The celery is then stood close together in the furrow and soil is thrown well up around it. This banking with soil should be done gradually as the weather grows colder, leaving the tips of the leaves exposed and crowning the ridge with straw, hay, or leaves. As the ground begins to freeze the entire ridge should be covered with 3 to 4 inches of coarse stable manure.

VEGETABLE-STORAGE HOUSES.

Buyers and shippers often wish to store vegetables in large quantities. Growers also often wish to store large quantities of vegetables in a more convenient manner than the pit or trench. Houses for this purpose are based upon the same general principles as the fruit storage, in that the two main requisites are frost-proof walls and an efficient system of ventilation.

In Fig. 12 is shown the diagram of a commercial cabbage storage used with very good success. It is 200 feet long, 60 feet wide, and 24 feet to the roof. The walls are brick and have a 4-inch air-space in the centre. On the inside of the wall is a lining of water-proof paper and matched boards, making a frost-proof building.

The storage has an 18-foot alley running lengthwise through the centre, which space is taken up by a railroad-track, track-scales, and drives for filling the bins, which are on each side of the alley. As is shown in the diagram in Fig. 12, these bins are 3 x 17 feet and extending 20 feet high, but being divided into three sections, so that each bin is but 6 feet deep. The bins are made by nailing 4-inch slats on 2- x 4-inch studding, spacing the slats 4 inches apart. Between the bins is a 6-inch air-space, while between the outside of the bins and the walls of the building is a space of 2 feet for air-circulation. The bottoms of the bins are 2 feet above the floor of the building.

Ventilation.—Cabbage requires thorough ventilation in a storage building. Besides having large trap-doors overhead which may be opened when mechanical ventilation is not in operation, the building is equipped with a 60-inch exhaust-fan, driven by a 3-horse-power electric motor. To this is connected a 20-inch pipe which divides into two branches, each running horizontally over a row of bins, reducing in size until it is but 8 inches in diameter at the opposite end. From these main overhead ducts are 6-inch elbows at intervals of 12 feet, sucking the air from the tops of bins when fan is in motion. Underneath each row of bins is a cold-air duct 12 x 14 inches, with an opening under each bin. These connect with outside air by 10-inch pipes at intervals of 12 feet.

At night, when the outside air is cold, the exhaust-fan is operated, sucking warm and foul air from tops of bins and forcing it out of building. This suction causes cold air to be brought in from the outside through the cold-air ducts underneath bins, then to rise about and through the cabbage, cooling it and carrying off waste gases. In this way the air within the building is entirely changed in less than an hour of time and the cabbage is kept cool. During the day, when the outside air is warm, the building is closed up and kept cool within.

This storage is used only for cabbage. If a commercial potato storage was to be erected instead of a cabbage storage, the building needs to be lower, while the mechanical system of ventilation could be displaced by a system similar to that in the apple storage.

CELERY-STORAGE HOUSE.

Celery is very exacting in its storage requirements. It must be kept cool, but not at a freezing temperature; it must be rather moist, but well ventilated and accessible; no odours from other roots, from the heating apparatus, nor from any other source can be allowed in the storage. Besides these requirements, conditions must be such as to allow a slow growth.

To meet these conditions a storage-house similar to the diagram in Fig. 13 may be used to an advantage. This house may be built of any desired size. The one shown in the diagram is 16 feet wide, inside measurement. The walls are 18 inches thick, and in the centre of the masonry is a 2-inch air-space. The walls extend slightly above the surface of the ground and are capped with a 2-inch plank plate, which is held in place by a 2- x 6-inch tenon embedded in the masonry.

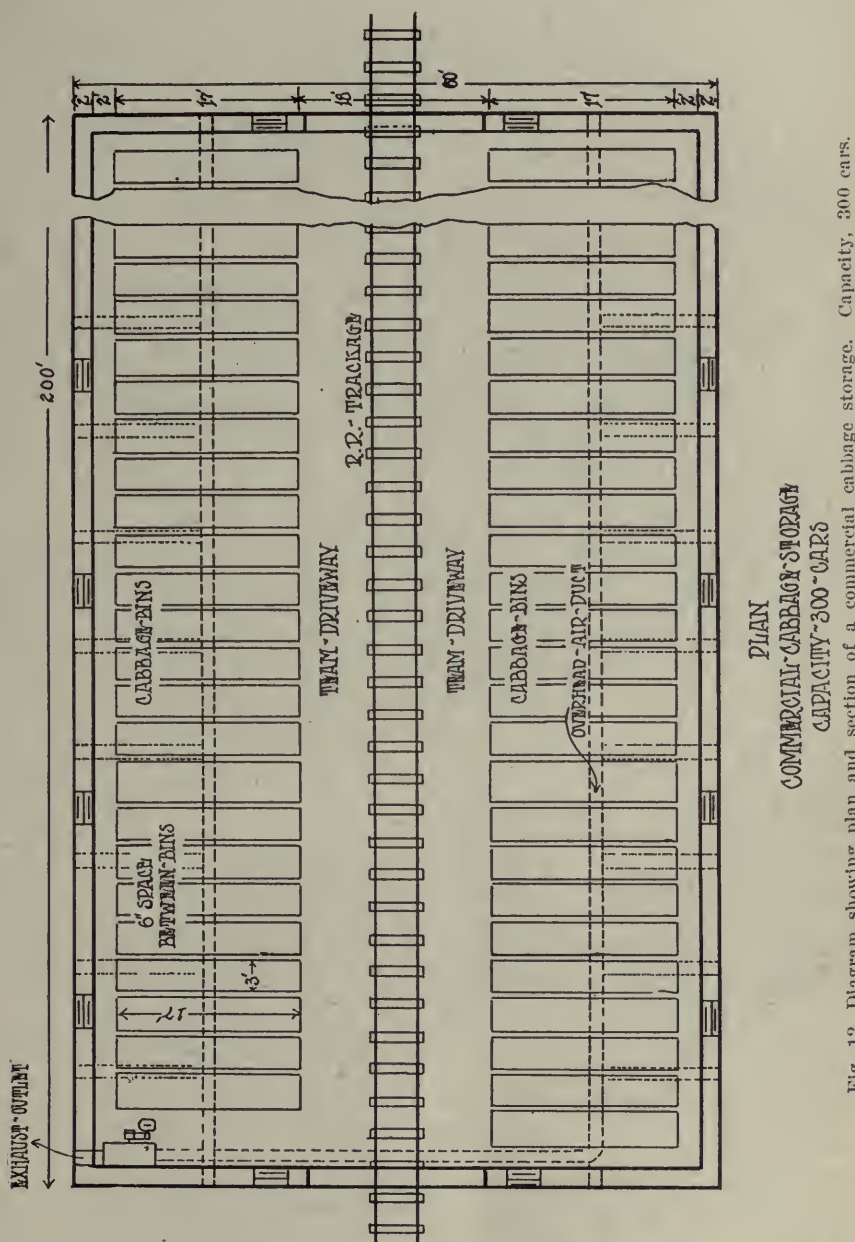
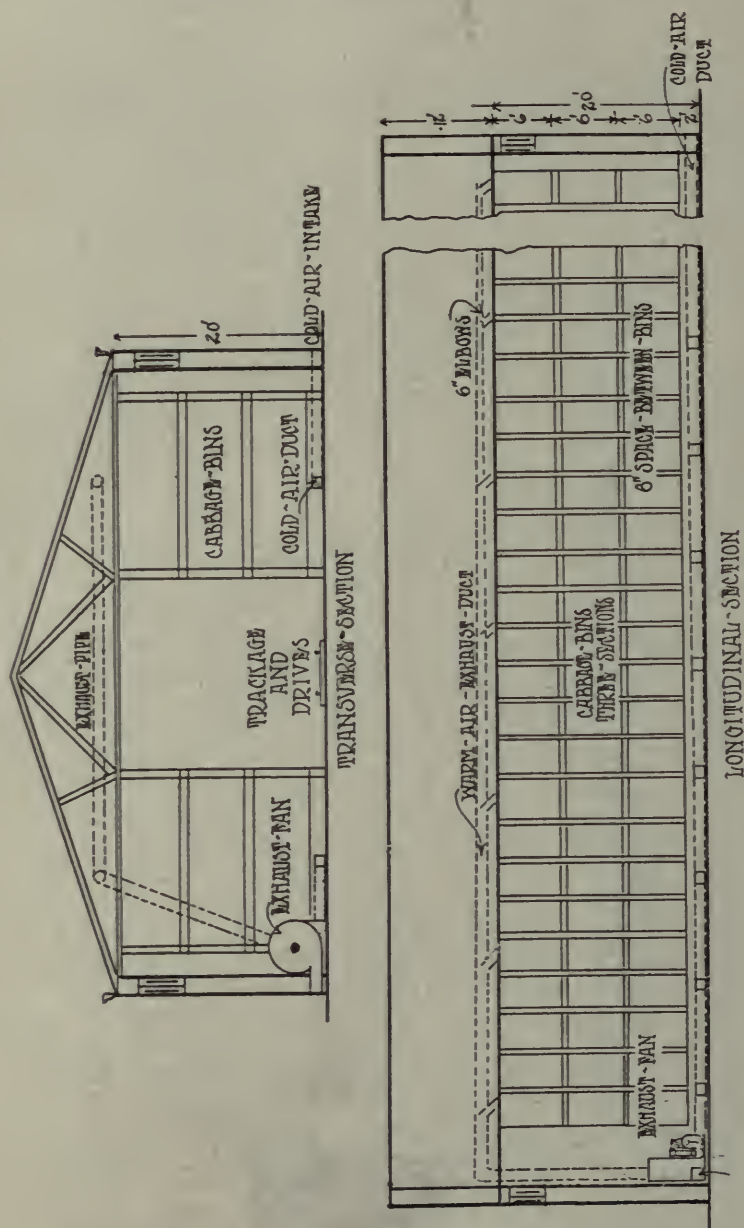


Fig. 12. Diagram showing plan and section of a commercial cabbage storage. Capacity, 300 cars.

The roof and ceiling are made up as follows: On 2- x 8-inch rafters is laid one ply of water-proof building-paper; if in a very cold climate or one where the winter temperature goes below 10° Fahr., $\frac{3}{8}$ -inch shiplap should be added after the W.P. paper; on 1-inch furring the roof-boards are laid, giving an inch air-space above the

rafters; on the under-side of the rafters is a layer of one-ply W.P. paper; ceiled under this is $\frac{7}{8}$ -inch T. and G. flooring. Joists are placed across from one rafter to the one on the opposite side, so that the ceiling proper is 7 feet 6 inches from the earth floor. Any roofing material desired may be placed on the roof-boards.

In the centre of the building and at intervals of 8 feet are ventilators extending to ventilator-stacks above the roof. These are 6 x 6 inches, with a valve at the



lower end which is opened at times when it is not too warm or too cold without. To further provide for the ventilation of the storage, the building has large doors at either end which are opened at night during the fall, so that the cold night air can be admitted.

For the storage of celery in a house of this kind, place a layer of loose, moist soil 4 to 5 inches deep on the bottom. A sandy loam is best for this purpose and should be thoroughly moistened. As is shown in Fig. 13, beds 6 to 8 feet wide are made to run the length of the storage, being bordered by 6-inch boards held 4 or 5 inches above the surface of the soil by stakes.

The celery is then carried into the storage from the field and transplanted in the soil so that the plants will almost touch when in place. This usually demands a space of 4 inches between plants. After the plants have been transplanted keep the temperature low, the air fresh, and the soil moist, although in doing so care must be taken not to allow the tops of the celery to remain wet.

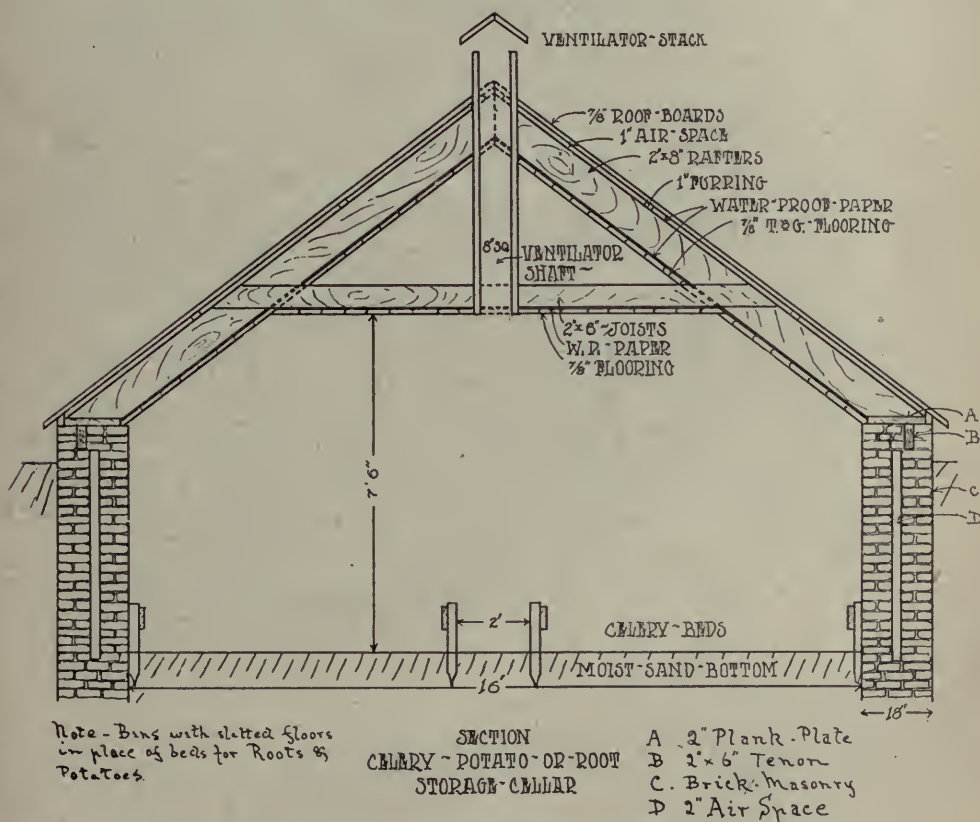


Fig. 13. Diagram showing the section of a celery storage. This building may be adapted to the storage of other vegetables by installing floor and bins.

This house may be used for potatoes and root-crops as well as for celery. If so used, bins should be built with slatted floors, allowing the air to pass underneath and up through the vegetables.

ONION STORAGE.

Although onion storage is a difficult problem, still in many trucking regions there are successful onion storages. The main requisites of onion storages are to have frost-proof construction; the floors are made of 1 1/4-inch material, leaving 1/2-inch space between each floor-strip and keeping the floor 6 to 8 inches above the earth bottom to provide good circulation of air.

In storing onions much depends on handling and storing. They must be thoroughly ripe and well cured. They must not be stored in tight boxes, barrels,

sacks, or piles. Slatted crates holding one bushel are best. Stack in tiers, leaving air-spaces between. Onions need to be well ventilated and must be kept free from successively freezing and thawing.

Besides the cold-storage of onions, another storage method is to freeze the bulbs and allow them to remain in a frozen condition till time for consumption or

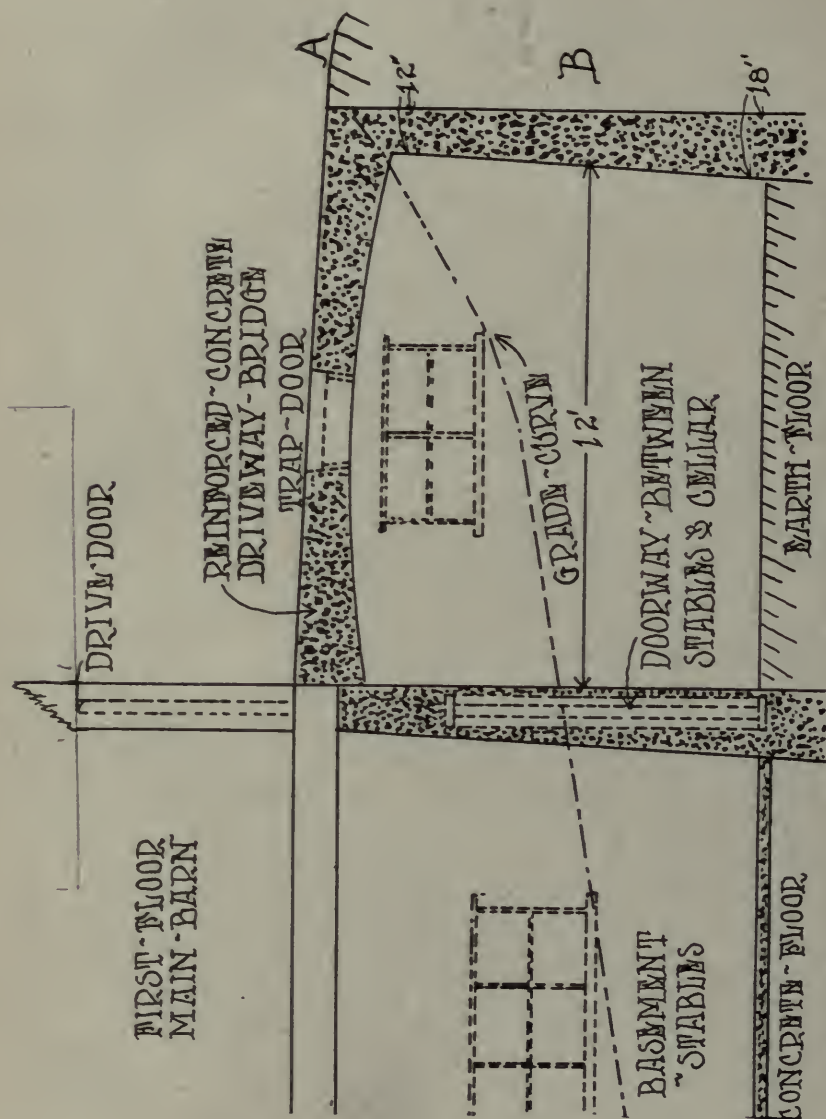


Fig. 14. Diagram of the section of a root cellar constructed underneath the drive bridge to a barn with basement.

marketing. This is a difficult method to use, and unless great care is used to keep their temperature below 30 degrees and still keep it from falling lower than 15 degrees, satisfaction may not be expected.

OTHER STORAGEES.

On the farm where vegetables are to be stored for home consumption the house cellar is the usual recourse. It is this kind of storage that results in the large loss cited in the introduction. Just a few bushels of potatoes, beets, or onions thrown

out as a loss on each farm aggregate a colossal national loss. Poor house cellars, and lack of attention and ignorance in preparing products for storage, probably result in the loss of 20 per cent. of all that is stored in this manner.

In using the house cellar for vegetables the presence of a furnace must be taken into consideration; the furnace must be partitioned off. Even if the heat of the furnace is avoided, the drying effect that it has upon the air is ruinous to fruit and vegetable storage. On the other hand, damp cellars with no air-circulation cause heavy loss from mould and decay, besides making the products unfit for domestic use. To prevent this, provide drainage; store the vegetables in crates well spaced apart and up from the earth floor; and build air-ducts from the lower half of the cellar windows to the space beneath the rack upon which the crates are stacked. Keep the walls whitewashed with lime and all refuse removed from the cellar, so as to keep the air as sweet and pure as possible.

When cellar conditions are made fit for storage, attention must be shown in storing the home supply of winter's produce. Select only varieties of fruits and vegetables that are known to keep well for the desired length of time. Place apples, pears, pumpkins, squashes, and other similar produce consisting of the fruits of plants in storage as soon as harvested, and keep in a low temperature by opening the cellar windows or ventilators during the night and closing them during the day. Handle all storage produce carefully, so as not to inflict bruises or injuries, whether they consist of the fruit, leaves, stems, or roots of plants. Onions, celery, cabbage, potatoes, and other odoriferous vegetables should be stored in a separate room from the apples.

Barn cellars, when properly built, may be used admirably for vegetable storages, and the advances made in the growing of root-crops, such as mangels, beets, etc., to make succulent feed for the stock during the winter is calling for more and more of this type of cellar. In building these the same methods should be employed as are used in the construction of the basement of the commercial fruit-storage house; ample walls and ceiling to prevent freezing, good drainage, and a floor that provides air-circulation are important features. In the case of roots stored for stock-feeding, the prevention of frost is not important unless the roots are to continually freeze and thaw out. A succession of freezing and thawing will be ruinous to the roots and must be prevented. However, roots need to be free from frost at feeding-time, and it is advisable to provide a frost-proof storage for them.

On the farm there are often very convenient places to build storages, rendered so by their natural surroundings. One of these that is used more often on the dairy-farm than on the fruit-farm is the cellar underneath the drive-bridge approaching a basement-style barn as is shown by the diagram in Fig. 14. These cellars are made with a trap-door in the concrete roof, so that the roots may be dumped in from above. Then by having a door between the cellar and the basement the roots are very handily cut and carried into the basement stables or pens. These make most excellent root-cellars and are used to a great extent on eastern dairy-farms.

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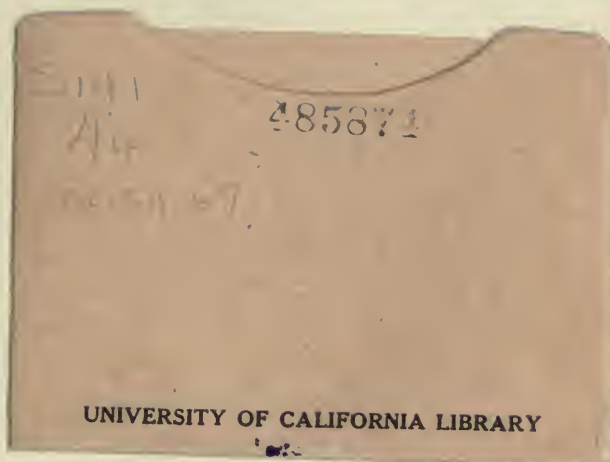
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